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A BIOLOGICAL EVALUATION OF SUMMERDALE, LITTLE SANDY, AND GREYS MOUNTAIN CAMPGROUNDS, BASS LAKE RANGER DISTRICT, SIERRA NATIONAL FOREST

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ABSTRACT

Summerdale, Little Sandy and Greys Mountain Campgrounds on the Bass Lake Ranger District were evaluated for pest problems which may affect management objectives for the sites. Pests noted varied by site, but included annosus root disease, true fir dwarf mistletoe, white pine blister rust, and gophers. Management alternatives to reduce pest impacts are presented and discussed for each of the three campgrounds.

INTRODUCTION

In response to a request from the Forest Supervisor, Sierra National Forest, a biological evaluation of the Summerdale, Little Sandy, and Greys Mountain Campgrounds on the Bass Lake Ranger District was conducted during the week of August 13-17, 1984. The evaluation was coordinated in the field with Walley McCray, Forest Landscape Architect, Mark Smith, Forest Silviculturist, and John Willis, Resource Officer, from the Bass Lake District.

The objective for recreational sites on the Sierra National Forest is to maintain or improve the existing outdoor recreational experience by, in part, minimizing adverse effects of insect and disease activities. The objectives of this evaluation were to identify existing and potential pest situations, to provide information on the expected future conditions of each of the three sites, and to provide the Bass Lake District with alternatives for integrating pest management considerations into a vegetation management plan for each of the three sites.

SUMMERDALE CAMPGROUND

Observations

Summerdale is located one mile south of the Yosemite National Park entrance at an elevation of 5000 feet. The 30 units are situated around the margin of a wet meadow and the western portion of the campground is adjacent to Big Creek. Tree cover is primarily cottonwoods with some willows. Conifers, including incense-cedar, white fir, ponderosa pine, and some sugar pine, occur primarily on the edges of the meadow, especially upslope on the eastern edge of the campground. Many of the cottonwoods were top-pruned about 10 years ago and numerous hazardous trees from developing decay were present when Forest Pest Management used the campground for a training session in 1979. Since then, the District has done an excellent job in removing many of the hazardous trees.

Relatively few pest problems were observed. Site-specific notes are attached to the map for the campground. The major problem noted was potentially hazardous cottonwoods scattered throughout the area. Decay was common in main boles and larger branches of the older trees. Some trees, at the entrance to unit 7 for example, had dead and decayed upper boles, but had numerous sprouts below. Much of the decay was associated with the previous top-pruning. Some cottonwoods within units had large, dead branches that are potentially hazardous. Signs of gopher activity were prevalent in the open meadow, especially near units 4 and 10. Minor pest situations noted included aphids galls on leaves of willows, and a leaf spot on cottonwood.

Management Alternatives

1. No Change in Current Management Direction. The cottonwoods with decay are, or will become, hazardous trees as they increase in size and the probability of them being broken off and causing damage during high winds increases. Dead and decayed branches and tops now present are also subject to failure. Because cottonwoods have relatively thin bark, they are easily wounded, especially in campground situations. Wounding from recreationists and other means will predispose the trees to various decay and canker-causing organisms, resulting in an increase in the number of potentially hazardous trees. Removal of companion sprouts and pruning of live branches that are greater than about 2 inches in diameter may expose heartwood and create wounds that heal slowly. This will present a favorable opportunity for the start of decay in the remaining sprouts and branches.

2. Tree Hazard Management. The District has recognized that defective trees may present a hazard to people and structures at Summerdale, and has instituted a hazardous tree removal program. Forest Pest Management can offer some guidelines to assist the District in recognizing hazardous trees and to prevent or reduce the development of hazardous trees in the future.

The principal defects in cottonwoods are heart and sap rots in the main bole and branches, and cankers. Heart rots in hardwood trunks commonly extend into main branches where they can cause a greater structural weakening than in the bole. Cottonwoods should be inspected annually for defects that could lead to breakage. When examining individual trees for defects, a systematic inspection

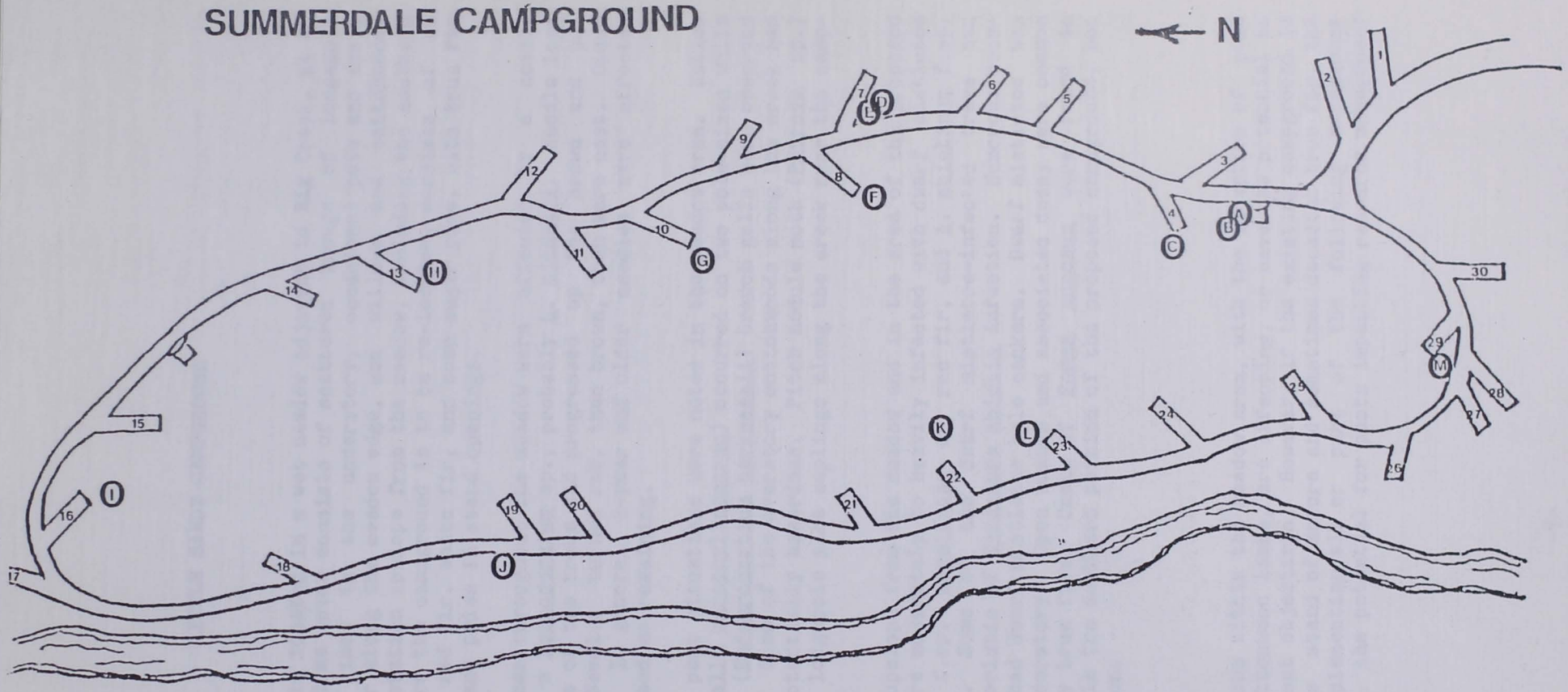
of the entire tree should be made. Dead tops that may become weakened by rot and break off should be noted. In the crown, look for hanging or cracked branches that should be removed and evidence of dead cambium and associated rot. Trunks should be examined for fungus conks, evidence of rot and hollowness in the heartwood where large branches have been sawn or broken off, cankers, and large open wounds. The presence of slim flux alone is not a sign that the tree is hazardous. It can occur in otherwise sound trees. However, slim flux is sometimes present on trees in a generally decadent condition. Defects noted should be recorded and systematic removal of trees or parts of trees, based on hazard estimate (probability of failure X probability of target impact X damage potential X target value), planned for.

Decay in living cottonwoods (and other trees) can be reduced by implementing management procedures that minimize conditions favorable for decay. Most fungi that cause decay require a wound to attack successfully. Reducing the incidence of wounding will reduce decay. When live-branch pruning, only branches that will leave wounds about 2 inches or less in width should be considered for removal. Larger wounds may expose heartwood and are slower to heal. Wounding also occurs when companion sprouts larger than 2 inches in diameter are removed. Trees originating from sprouts are generally more susceptible to decay than those of seedling origin. Decay can enter sprouts either directly from the parent stump or through the opening left in the base of sprouts by decay of the parent stumps. Decay in sprouts can be diminished by reducing the number of stems in sprout clumps, by promoting sprouts originating from small, decay-free stumps, and by promoting the growth of seedlings rather than sprouts. Reducing the number of sprouts in a clump should be done at an early age. Surfaces exposed on sprouts less than about 20 years old will be mainly sapwood, and subject to less decay than heartwood.

3. Encourage Other Tree Species. Portions of the campground already contain a number of conifers. For example, the incense-cedar and ponderosa pines at sites 13 and 15 would provide sufficient shading and screening between sites even if all the cottonwoods were removed. Favoring the conifers present over the cottonwoods would reduce the number of defective and potentially hazardous trees as well as increase diversity in the vegetative cover. Planting of conifers would also be beneficial. Numerous giant sequoia planted near the campground at Fish Camp appear to be growing quite well. Other hardwoods and shrubs suited to the relatively wet soil conditions at Summerdale could be planted. Although sugar pine grows in the area, it should not be planted unless rust resistant seedlings are used. The site is favorable for white pine blister rust, and the disease is present within a few miles of Summerdale.

4. Control Gophers. The meadow area at Summerdale has evidence of gopher activity. Without control, planting in this area may be unsuccessful. The need for control efforts depends on management objectives as well as on pocket gopher activity levels determined by mound surveys (see Animal Damage Control Handbook, FSH 2609.22). Reducing or preventing gopher damage can be accomplished by 1) direct reduction in numbers by trapping, 2) preventing population increases by controlling grasses and forbs, and by 3) the use of physical barriers such as "Vexar" tubing around shoots and roots of seedlings.

SUMMERDALE CAMPGROUND



SITE SPECIFIC OBSERVATIONS

A CW with dead upper bole; overhangs restroom

B CW's with heart rot, open wounds, wetwood

C Gopher activity in meadow

D Two CW's with internal decay; leaning over site

E CW with decayed bole; over picnic table

F Dead branch over fireplace

G Five CW's with decay in main bole; gopher activity

H CW's with decay in main bole; wetwood

I CW's with heart rot; dead branches over site

J Two large CW with decay; next to road

K CW with dead branches, internal decay

L CW's with dead branches over picnic table

M CW with internal decay; leaning into site

LITTLE SANDY CAMPGROUND

Observations

This 10 unit campground is located in a wet meadow adjacent to Big Creek, at an elevation of 6100 feet. Tree cover consists of scattered groups of lodgepole pines, some ponderosa pines in the understory, occasional pole and small sawtimber-sized white fir along the meadow edge, and willows and cottonwoods along the creek. Vegetation upslope from the meadow, including the southern and western portions where the campground is to be re-located, consists of an overstory of overmature red fir, white fir, and some sugar pine, with true fir and sugar pine saplings and poles in stand openings.

Many of the lodgepole pines throughout the meadow were affected by a needle cast disease, caused by a Lophodermium sp., probably L. pinastri. Needle loss was severe on lower parts of the trees and progressed up the crown and out towards new growth. Needles turned red, then brown, then were cast. Older needles were cast first. In general, 2-year and older needles were affected with only current year needles remaining.

Other, relatively minor, pest situations were noted in the meadow area. Yellow witches broom (Melampsorella caryophyllacearum) occurred on two pole-sized white firs. Western gall rust (Endocronartium harknessii) branch galls were observed on one lodgepole pine. Some of the overstory cottonwoods along the creek had dead branches that are potentially hazardous. Pitch nodule moth (Petrova sp.) damage was common on lodgepole pine saplings along the creek near the campground entrance.

The overstory true firs upslope from the meadow and in the area of the proposed campground relocation were moderately to heavily infected with dwarf mistletoe (Arcethobium abietinum f.sp. magnificae on red fir, and A. abietinum f.sp. concoloris on white fir). Some of the dwarf mistletoe-infected trees had branch flagging characteristic of Cytospora abietis infection. Numerous decadent overstory red firs had dwarf mistletoe bole cankers. Dwarf mistletoe was not observed in the understory. Open wounds and associated decay were common in butt logs of overstory true firs. Conks of Fomes annosus were found in hollow true fir stumps in the southern portion of the proposed campground, but not in the western portion.

Management Alternatives

None of the pest situations within the meadow area, with the exception of some potentially hazardous cottonwood limbs, are affecting, or have the potential to affect, resource management objectives. However, if the existing campground is moved upslope into the stand of mature and sometimes decadent true fir, the District may consider implementing all or part of the following management alternatives to reduce the potential for pests impacting resource management objectives.

1. No Change in Current Management Direction. The current outbreak of lodgepole needle cast appeared spectacular, but will subside and damage few, if any, trees. Some growth loss of severely infected trees may occur, but this will not interfere with the recreational objectives for the site. Future periodic outbreaks will occur when environmental conditions that favor the disease, especially high relative humidity during the spring and summer when sporulation and infection occur, are present. Decay will likely increase in the cottonwoods and decayed branches and entire trees may fail during periods of high recreational use.

The pests that occur upslope in the true fir stand will adversely affect management objectives if the campground is moved there. True fir dwarf mistletoe will intensify in the overstory trees and spread to adjacent understory true fir. Decay may develop in dwarf mistletoe bole cankers and create potentially hazardous trees. Trees with substantial annosus root and butt rot, as well as trees with internal decay caused by other fungi, will have a high probability of failure, especially during winter storms. Additional annosus centers in true fir may be created by infection of freshly cut stumps and wounds when trees are removed for campground construction, when blow-down occurs, or when hazardous trees are removed.

2. Dwarf Mistletoe Management. If campground units are to be moved upslope into the true fir stand, the District may decide that dwarf mistletoe will have a negative impact on the site. If so, various suppression tactics are available for reducing the impact of true fir dwarf mistletoe in recreation sites.

a. Remove infected overstory trees to protect regeneration. Infected overstory trees can be removed to eliminate the source of inoculum for infection of understory trees. The understory can then be thinned to remove any dwarf mistletoe infections present. The objective of overstory removal is not to eliminate the dwarf mistletoe completely, but to decrease the amount of inoculum and to remove heavily infected overstory trees that are stressed and susceptible to fir engraver attack. Non-infected trees should be favored as leave trees.

b. Thin understory true fir. Thinning will aid in maintaining optimum growth of residuals and will reduce tree stress. If the overstory source of infection is removed, lightly infected understory true fir growing at optimum stocking levels on good sites most likely will vertically outgrow the dwarf mistletoe. All freshly cut stumps created when thinning should be treated with borax to prevent infection by F. annosus.

Thinning dense aggregations of true fir will, in addition to minimizing the impact of dwarf mistletoe, minimize opportunities for root contact and subsequent spread of F. annosus, and reduce the risk of fir engraver attack of stressed trees.

c. Encourage tree species diversity. A mix of non-susceptible species in dwarf mistletoe-infected stands provides a barrier to spread of the parasite. Increasing, or at least maintaining, the present species mix would reduce the future impact of the disease. Favoring the existing sugar pines should be

considered when road and unit placement plans are implemented. The two true fir dwarf mistletoes are host specific. Favoring white fir regeneration in areas of infected red fir overstory would be beneficial.

3. Annosus Root Disease Management. Annosus root disease is having limited impact now in the true fir stand because of area's use for dispersed recreation only. However, if camp sites are to be constructed in the area, the disease will adversely impact resource management objectives and should be considered during and after unit development.

a. Prevent infections. The most effective control for annosus root disease is prevention. The probability of new centers forming and the resulting adverse effects of the disease can be reduced by the application of borax (sodium tetraborate decahydrate, EPA Reg. No. 1624-94) to all freshly-cut conifer stumps. This treatment is directed by the Forest Service Manual (FSM 3205, 2331.33, R-5 Supplement No. 90) for all developed recreation sites in California National Forests.

Borax treatment is 90% effective in preventing establishment of new infection centers. The chemical is toxic to spores of F. annosus, but has no effect on existing underground infections. Based on surveys elsewhere, about 3% of the true fir in the area would be expected to be already infected.

b. Thin. Thinning active annosus centers may increase the tolerance of true fir to infection through increasing their rate of root regeneration and replacement, and will minimize opportunities for root contact and subsequent spread. In addition, thinning will alleviate overstocking as a predisposing factor to insect attack and will reduce the impact of dwarf mistletoe.

c. Utilize root disease openings. When the area is developed, existing openings can be utilized for parking, restrooms or other facilities rather than removing trees to make space for them. Additional mortality, which could create hazardous tree conditions, may eventually occur around the edges of these areas as the fungus spreads via root contact.

d. Species conversion. Converting the stand, over time, from true fir to pine will have two beneficial effects. First, pines are generally resistant to the strain of F. annosus present on true fir. Favoring pines over true fir will minimize root contact among firs and reduce the spread and impact of the root disease. Second, because pines are less susceptible than true fir to wounding and subsequent decay, pines are potentially less hazardous than true fir in campground situations.

4. Tree Hazard Management. Potentially hazardous trees (those severely infected with dwarf mistletoe, with open dwarf mistletoe bole cankers, with basal wounds, and those infected with annosus root disease) are present in the stand upslope, and additional hazardous trees will likely develop during construction of roads, sites, and facilities. Removal of trees rated as high hazard should be considered during construction phases. Attempts to minimize development of hazardous trees during construction by protecting residual trees from wounding should be made. The area should be rated again for hazard after construction, and a procedure for a formal inspection on a regular basis to identify hazardous trees implemented.

GREYS MOUNTAIN CAMPGROUND

Observations

This 23 unit campground is located adjacent to the North Fork of Willow Creek, at an elevation of 5200 feet. Forest type is Mixed Conifer, with the overstory consisting of white fir, incense-cedar, ponderosa pine and sugar pine. The same species occur in the understory where reproduction is present. White fir predominates upslope along the eastern edge of the campground. Cottonwoods and some willows occur adjacent to Willow Creek. Planted giant sequoia saplings and poles are present in portions of the existing loop and in the meadow formerly used for walk-in camp sites. The center of the loop is an open, rocky area, characterized by a lack of vegetation, loose soil, and evi- dence of uncontrolled vehicular traffic.

The white fir had two pest problems that may interfere with resource management objectives for the site. Dwarf mistletoe (Arceuthobium abietinum f.sp. concoloris) was common on overstory white fir throughout the campground. Some trees (vicinity of units 1, 2, 3, 4, and 23) were heavily infected, with large witches' brooms present. Dwarf mistletoe bole cankers were common on some trees (near unit 8). Branch flagging, characteristic of Cytospora canker (Cytospora abietis), occurred on both overstory and understory white fir, but dwarf mistletoe was not associated with the flagging on understory trees. Conks of Fomes annosus were found in white fir stumps at the eastern edge of the campground (behind units 10 and 11). The numerous stumps in this area were evidence of white fir dying over a period of years, probably from annosus root disease.

White pine blister rust (Cronartium ribicola) was common on most of the sugar pines. Lethal branch and bole cankers occurred on trees ranging in size from seedlings to small sawtimber. Some sugar pine saplings adjacent to the creek had been girdled and killed by the rust. Branch cankers 30 feet in the crown were not uncommon.

Some potentially hazardous trees were present. Dead overstory cottonwoods occurred at units 17, 19, and 23. Some cottonwoods had dead branches over units 19 and 21. A dead 30 foot tall ponderosa pine was present between units 16 and 17. Several overstory white fir at unit 22, and one each at unit 15 and 8, had large basal wounds with associated decay.

Management Alternatives

1. No Change in Current Management Direction. White fir dwarf mistletoe will intensify in trees already infected and spread to adjacent understory trees to perpetuate the disease. Decay will develop in dwarf mistletoe bole cankers and create potentially hazardous trees. Annosus root disease centers now present will continue to expand as long as there are root contacts with surrounding live white firs. Trees with substantial annosus root and butt rot will have a high probability of failure, especially during severe storms. When blow-down occurs or when hazardous trees are removed, new annosus centers may be created by infection of wounds and freshly-cut stumps by spores of the fungus. Sugar pine will become a minor component of the stand as white pine blister rust

intensifies and continues to girdle and kill sugar pine reproduction. The lack of barriers to control traffic along the river and in the center loop will limit establishment of vegetation and will result in continued soil compaction and erosion.

2. Dwarf Mistletoe Management. The current and potential impacts of white fir dwarf mistletoe at Greys Mountain can be reduced by various suppression tactics, including:

a. Removal of infected overstory trees to protect regeneration. To prevent infection of understory trees, the infected overstory white fir can be removed to eliminate the source of inoculum. Removal of heavily infected overstory trees with open, dwarf mistletoe bole cankers would also reduce the number of potentially hazardous trees present in the campground.

b. Thinning. Thinning of infested stands will aid in maintaining optimum growth of residuals and will reduce tree stress. Following release and removal of the overstory source of inoculum, lightly infected residuals most likely will vertically outgrow the dwarf mistletoe. All freshly cut stumps created when thinning should be treated with borax to prevent initiation of annosus root disease centers. Thinning will minimize opportunities for root contact and subsequent spread of F. annosus in existing root disease centers. Increased tree vigor following thinning will also reduce the risk of bark beetle attack.

c. Encourage tree species diversity. A mix of nonsusceptible species in dwarf mistletoe-infested portions of the campground will provide a physical barrier to spread of white fir dwarf mistletoe. Encouraging non-fir species already present, as well as planting of other species, would also provide a barrier to spread of F. annosus via fir to fir root contact. Planting of sugar pine should not be considered unless rust-resistant stock is used. Non rust-resistant stock will most likely become infected with white pine blister rust.

3. Annosus Root Disease Management. The formation of additional annosus root disease centers at Greys Mountain can be reduced by the application of borax (sodium tetraborate decahydrate, EPA Reg. No. 1624-94) to all freshly-cut conifer stumps in the campground. Application of borax in recreation sites is required by the Forest Service Manual (FSM 3205, 2331.33, R-5 Supplement No. 90). Basal wounds on true fir are also entry courts for F. annosus. Wounding of residual trees when thinning or when removing trees for other reasons should be avoided to prevent subsequent decay. Wounded trees should be considered for removal.

The impact of existing annosus root disease centers on recreation objectives for the campground can be reduced. The strain of F. annosus on true fir will seldom move to and infect pines, and hardwood trees and shrubs are resistant or immune. Therefore, strategies already mentioned for dwarf mistletoe management, such as thinning and encouraging or planting of non-fir vegetation, will also limit the spread of the root disease.

4. Tree Hazard Management. A hazardous tree identification and removal program could be incorporated into the overall management program for the campground. Trees that are, or will become, potential hazards include white firs with dwarf mistletoe bole infections, trees with basal wounds, and cottonwoods

that are dead or have dead limbs or tops. Slow-growing, sawtimber-size white firs within annosus centers may also become hazards because of instability in high winds due to insufficient supporting roots.

In addition to removal of hazardous trees, attempts to minimize formation of hazardous trees could be implemented. These could include protection of residual trees from wounding and restricting vehicles to specified areas to decrease soil compaction and reduce tree stress.

APPENDIX

BIOLOGY OF PEST ORGANISMS

Following are summaries of the biologies of pests causing mortality or damage at Summerdale, Little Sandy, and Greys Mountain campgrounds.

Dwarf Mistletoes. Red fir (A. abietinum f.sp. magnificae); white fir (A. abietinum f.sp. concoloris): Red fir is the only host for red fir dwarf mistletoe, just as white fir dwarf mistletoe infects only white fir. Other conifers are rarely infected and hardwoods are immune to these pathogens. The pathogens are obligate parasites, obtaining their nutrients, minerals and water from the host.

These parasites are dioecious, perennial higher plants that produce seeds as their means of spread. In the fall of the year when the fruit falls from the stem, the seed is ejected upward and outward. The seed adheres to any surface it contacts. When the seed lands in the crown of a susceptible host tree, it adheres to a needle or limb and overwinters. The following spring it germinates and penetrates the limb. For the next 2 to 4 years the plant grows in the tree limb, developing a root-like endophytic system in the inner bark and outer sapwood. It then produces aerial shoots and in another 2 to 4 years produces reproductive structures.

Spread of dwarf mistletoe is limited to the distance traveled by the seed, which from overstory to understory is usually 20 to 60 feet, but may be as much as 100 feet if wind assists the seeds. As a rule of thumb, dwarf mistletoe can spread horizontally to the understory a distance equal to the height of the infection in the overstory tree. Because of the various limits to spread, such as height of the source plant, angle of discharge, wind velocity, stand density, etc., the actual spread rate through an even-aged stand is about 1 to 2 feet per year.

Annosus Root Disease (Fomes annosus). Fomes annosus is a fungus that attacks a wide range of woody plants, causing a decay of the roots and lower bole and death of sapwood and cambium. All conifer species in California are susceptible to the fungus. Hardwood species are rarely damaged or killed. Infected pines are usually killed rather rapidly when the fungus girdles the root collar. In contrast, older true firs can survive infection for many years although butt and root rot may become extensive, resulting in tree weakening and windthrow.

During periods favorable to the fungus, fruiting bodies form in decayed stumps, under the bark of dead trees, or in the duff at the root collar. The fungus becomes established in freshly cut stumps from air-borne spores produced by the conks, and then grows into the root system. True firs can also be infected by spores invading fresh basal wounds. The fungus then spreads to healthy roots of surrounding susceptible conifers via root contacts. In general, infections will cross from pine to true fir; however, rarely is the fungus observed to cross from true fir to pine. Local spread of the fungus outward from a stump typically results in the formation of a disease center, with dead trees in the

center and fading trees on the margin. These centers usually continue to enlarge until they reach barriers such as openings in the stand or groups of non-susceptible plants.

The fungus may remain alive for as long as 50 years as a saprophyte in infected roots and stumps. Young susceptible tree species often become infected and die after their roots contact old infected root systems in the soil.

Lophodermium Needle Cast (Lophodermium pinastri). Lophodermium needle cast is found on many species of pine throughout the world. Brown spots, often with yellow margins, are produced on needles in the spring as a result of infection the previous year. These infected needles begin yellowing and turning brown in late spring. Fruiting bodies of the fungus develop on dead needles on the tree or on the ground. Mature fruiting bodies look like tiny black football-shaped structures with a longitudinal slit down the center. During moist weather, the fruiting bodies open and forcibly discharge spores which are carried by the wind to adjacent healthy needles or trees. When those spores land on needles, they germinate and infect.

By late fall, most of the dead needles are cast, leaving only current year needles on the tree. Most trees survive by the development of new needles the following spring. These new needles become infected in late summer and fall and the disease cycle is repeated. Few trees are killed by defoliation, but sustained needle loss will eventually reduce the overall growth rate.

White Pine Blister Rust (Cronartium ribicola). White pine blister rust is caused by an obligate parasite that attacks sugar and western white pines and several species of Ribes. The fungus needs the two alternate hosts to survive, spending part of its life on 5-needled pines and the other on Ribes. Infection of pines results in branch mortality, top kill, and tree mortality.

Spores produced by the fungus in the spring on pine bole or branch cankers are wind-disseminated to Ribes were they infect the leaves. Spores produced in orange pustules on the underside of the leaves reinfect Ribes throughout the summer, resulting in an intensification of the rust. Another spore stage forms on Ribes leaves in the fall. These spores are wind-disseminated to pines and infect current year needles. Following infection, the fungus grows from the needle into the branch and forms a canker. After 2 or 3 years, spores are produced on the cankers and are spread to Ribes to continue the cycle. Although blister rust may spread hundreds of miles from pines to Ribes, its spread from Ribes back to pines is usually limited to a few hundred feet.

Branch cankers continue to enlarge as the fungus invades additional tissues and moves toward the bole. Branch cankers within 24 inches of the bole will eventually form bole cankers. Bole cankers result in girdling and death of the tree above the canker. Cankers whose closest margins are more than 24 inches from the main bole are unlikely to reach the bole and only branch flagging will occur.

Environmental conditions are critical during the infection process and limit the disease most years. Moisture and low temperatures favor infection of both hosts, and must coincide with spore dispersal for infection to occur. In California, these conditions occur only infrequently, usually in cool moist sites such as stream bottoms or around meadows. In so called "wave years" when

these favorable conditions occur, high levels of infection can result. Wave years have occurred at approximately ten-year intervals in the past. As one moves from sites most favorable for rust to less faovrable sites, the frequency of wave years decreases.

Pocket Gopher (Thomomys bottae). Pocket gophers live in closed burrow systems and spend most of their time below ground. The crescent-shaped mounds and plugged burrow entrances are major signs of gopher presence and activity. These animals are solitary except during the breeding season when young are being raised. Pocket gophers eat succulent underground parts of plants although they may graze above ground on plants near burrow openings. Breeding occurs in early spring when green forage is plentiful. Litters of 4 to 8 young are born after a gestation period of 18 to 19 days. An annual turnover of more than 75 percent of the population is common. Young disperse, usually above ground, in late summer. Mound-building activity is most common during the late summer or early fall when young are dispersing and establishing their own burrows and adults are enlarging their systems in preparation for winter. Pocket gophers are active year round and even burrow through snow. Where preferred forbs and grasses are lacking, pocket gophers may feed on the roots of large trees.